

Parity nonconservation effect in the resonance elastic electron scattering on heavy He-like ions

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Abstract

We investigate the parity nonconservation effect in the elastic scattering of polarized electrons on heavy He-like ions, being initially in the ground state. The enhancement of the parity violation is achieved by tuning the energy of the incident electron in resonance with quasidegenerate doubly-excited states of the corresponding Li-like ion. We consider two possible scenarios. In the first one we assume that the polarization of the scattered electron is measured, while in the second one it is not detected.

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I. INTRODUCTION

Investigations of the parity violation in the domain of atomic physics originate from consideration of the PNC effects in neutral systems (see Refs. [1–3] and references therein). The most accurate up to date measurement of the PNC was achieved for ^{133}Cs atom [4, 5]. These experimental data being coupled with the corresponding theoretical calculations of the same accuracy level (see Refs. [6–8] and references therein) provided the best verification of the electroweak sector of the Standard Model at low-energy regime. However, the precise calculations of the PNC effects in neutral systems are very difficult task. For this reason, the investigations of the PNC effects in heavy few-electron systems where the interelectronic interaction can be calculated accurately by means of the perturbation theory in the parameter $1/Z$ (Z is the nuclear charge number) seem very promising.

Gorshkov and Labzowsky [9] were first who considered highly-charged ions as a proper tool for measuring the PNC effect. To date, various theoretical scenarios were proposed to study the P-odd asymmetry in highly-charged ions. The PNC effect in the process of Auger decay of the He-like uranium was studied by Pindzola [10]. Gribakin *et al.* [11] discussed the parity violation in the process of dielectronic recombination of polarized electrons with H-like ions. A similar process for the case of He-like ions was investigated in Ref. [12]. The PNC effect in the process of radiative recombination of electron with H-like ions was studied in several works [13–15]. The parity violation on the laser-induced transition was considered for heavy He-like ions in Ref. [16] and for heavy Be-like ions in Ref. [17].

Though the PNC effect in highly-charged ions was extensively studied, the influence of the weak interaction on the process of electron scattering by a heavy ion has not yet been investigated. In the present work we study the PNC effect in the elastic scattering of polarized electrons by heavy He-like ions, being initially in the ground state. In order to enhance the parity violation we assume that the energy of the incident electron is tuned in resonance with close-lying opposite-parity $[(1s2s)_0 n\kappa]_{1/2}$ and $[(1s2p_{1/2})_0 n\kappa]_{1/2}$ states of the corresponding Li-like ions [18].

The relativistic units ($m_e = \hbar = c = 1$) and the Heaviside charge unit ($\alpha = e^2 / (4\pi)$) are used in the paper.

II. BASIC FORMALISM

We consider the resonance elastic scattering of an electron with asymptotic four-momentum $(\varepsilon, \mathbf{p}_i)$ and polarization μ_i by a heavy He-like ion being initially in the ground $(1s)^2$ state. It is assumed that the electron energy is tuned in resonance with doubly-excited quasidegenerate opposite-parity d_1 or d_2 states. The scattered electron is characterized by four-momentum $(\varepsilon, \mathbf{p}_f)$ and polarization μ_f .

Let us start with the consideration of the parity conserving part of the process amplitude. We construct this amplitude by means of the $1/Z$ perturbation theory up to the second order:

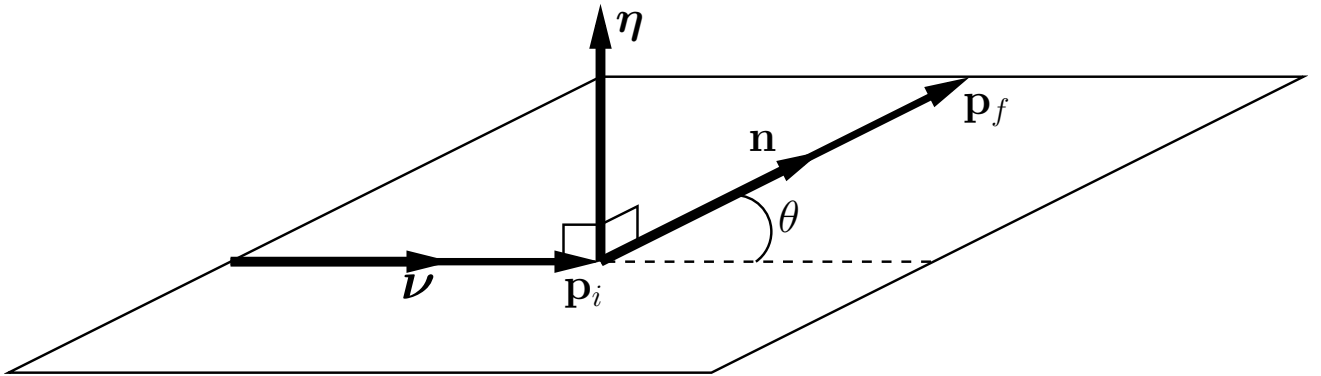
$$\tau_{\mu_f \mu_i}^{\text{PC}} = \tau_{\mu_f \mu_i}^{(0)} + \tau_{\mu_f \mu_i}^{(1, \text{dir})} + \tau_{\mu_f \mu_i}^{(1, \text{exc})} + \tau_{\mu_f \mu_i}^{(2)}, \quad (1)$$

where the first order contribution is separated into two terms which correspond to the direct and exchange parts of the interelectronic interaction. The sum of the zero-order and direct first-order terms can be written as follows [19]:

$$\tau_{\mu_f \mu_i}^{(0)} + \tau_{\mu_f \mu_i}^{(1, \text{dir})} = \chi_{1/2\mu_f}^\dagger(\mathbf{n}) (A + 2B\boldsymbol{\eta} \cdot \mathbf{S}) \chi_{1/2\mu_i}(\boldsymbol{\nu}), \quad (2)$$

where \mathbf{S} is the spin operator, $\boldsymbol{\nu}$ and \mathbf{n} are the unit vectors in the \mathbf{p}_i and \mathbf{p}_f directions (see Fig. 1), respectively, and $\boldsymbol{\eta} = [\boldsymbol{\nu} \times \mathbf{n}] / |[\boldsymbol{\nu} \times \mathbf{n}]|$. The two-component $\chi_{1/2\mu_i}(\boldsymbol{\nu})$ function is an eigenfunction

FIG. 1. Geometry for the resonance elastic electron scattering in the ion rest frame. The reaction plane is formed by \mathbf{p}_i and \mathbf{p}_f vectors, which denote the momentums of the incident and outgoing electrons, respectively. The normal to this plane is described by the unit vector $\boldsymbol{\eta} = [\boldsymbol{\nu} \times \mathbf{n}] / |[\boldsymbol{\nu} \times \mathbf{n}]|$ where $\boldsymbol{\nu} = \mathbf{p}_i / |\mathbf{p}_i|$ and $\mathbf{n} = \mathbf{p}_f / |\mathbf{p}_f|$.



of the $\mathbf{S} \cdot \boldsymbol{\nu}$ operator with an eigenvalue μ_i and $\chi_{1/2\mu_f}(\mathbf{n})$ satisfies $(\mathbf{S} \cdot \mathbf{n}) \chi_{1/2\mu_f}(\mathbf{n}) = \mu_f \chi_{1/2\mu_f}(\mathbf{n})$.

The scattering amplitudes A and B are defined as [20]:

$$A = \frac{1}{2ip_f} \sum_{l=0}^{\infty} \{ (l+1) [\exp(2i\delta_{l+1/2,l}) - 1] + l [\exp(2i\delta_{l-1/2,l}) - 1] \} P_l(\cos \theta), \quad (3)$$

$$B = \frac{1}{2p_f} \sum_{l=1}^{\infty} [\exp(2i\delta_{l+1/2,l}) - \exp(2i\delta_{l-1/2,l})] P_l^1(\cos \theta). \quad (4)$$

Here p_f is the momentum of the scattering electron, P_l and P_l^1 are the Legendre polynomials and associate Legendre functions, respectively, and θ is the scattering angle. The phase shifts $\delta_{j,l}$ for the total angular j and the orbital l momenta are determined from the asymptotic behaviour of the Dirac equation solutions in the scattering potential $V(r) = V_{\text{nuc}}(r) + V_{\text{scr}}(r)$. Here V_{nuc} is the electrostatic potential of the extended nucleus and V_{scr} is the screening potential of the $(1s)^2$ shell:

$$V_{\text{scr}}(r) = 2\alpha \int_0^{\infty} \frac{dr'}{r_{>}} [G_{1s}^2(r') + F_{1s}^2(r')], \quad (5)$$

where $r_{>}$ is the greater of r and r' , $G_{1s}(r)$ and $F_{1s}(r)$ are the upper and lower components of the radial wave function of one-electron $1s$ state, respectively. Since $V(r) \sim (Z-2)/r$ for large r , the scattering amplitudes defining by Eqs. (3) and (4) are divergent as they stand. Nevertheless, one can obtain the convergent expression for A and B utilizing the regularization procedure [21–24] which deals with the pure Coulomb potential. The deviation of the scattering potential from the Coulomb one is accounted for using the method described in Ref. [25].

The exchange first-order amplitude $\tau_{\mu_f \mu_i}^{(1, \text{exc})}$ is constructed by subtraction of the terms corresponding to the direct part of the interelectronic interaction from $\tau_{\mu_f \mu_i}^{(1)} = (2\pi)^2 \varepsilon \langle \Psi_f | I | \Psi_i \rangle$ (see Refs. [26, 27] for details). Here I is the operator of the interelectronic interaction, $|\Psi_i\rangle$ and $|\Psi_f\rangle$ are the wave functions of the initial and final states of the system, respectively. Due to the fact that for heavy highly-charged ions the electron-electron interaction is suppressed by a factor $1/Z$ compared to the electron-nucleus Coulomb interaction, we can utilize the one-electron approximation. In this approach the wave functions of the initial and final states are given by

$$\Psi_{\mathbf{p}\mu, JM}(\mathbf{x}_1, \mathbf{x}_2, \mathbf{x}_3) = A_N \sum_{\mathcal{P}} (-1)^{\mathcal{P}} \mathcal{P} \sum_{m_1 m_2} C_{j_1 m_1, j_2 m_2}^{JM} \psi_{n_1 \kappa_1 m_1}(\mathbf{x}_1) \psi_{n_2 \kappa_2 m_2}(\mathbf{x}_2) \psi_{\mathbf{p}\mu}(\mathbf{x}_3). \quad (6)$$

Here $\psi_{n\kappa m}$ is the one-electron bound-state Dirac wave function and $\psi_{\mathbf{p}\mu}$ is the continuum Dirac state wave function with asymptotic momentum \mathbf{p} and helicity μ (spin projection onto the momentum direction). The normalization factor $A_N = 1/\sqrt{2 \cdot 3!}$ for equivalent bound electrons and $A_N = 1/\sqrt{3!}$ otherwise, $C_{j_1 m_1, j_2 m_2}^{JM}$ is the Clebsch-Gordan coefficient, $(-1)^{\mathcal{P}}$ is the permutation parity, and \mathcal{P} is the

permutation operator. The explicit expression for the continuum Dirac wave function can be written as [28, 29]

$$\psi_{\mathbf{p}\mu}^{(\pm)}(\mathbf{r}) = \frac{1}{\sqrt{4\pi}} \cdot \frac{1}{\sqrt{\varepsilon\mathbf{p}}} \sum_{\kappa m_j} C_{l0, 1/2\mu}^{j\mu} i^l \sqrt{2l+1} e^{\pm i\delta_{j,l}} D_{m_j\mu}^j(\mathbf{z} \rightarrow \mathbf{p}) \psi_{\varepsilon\kappa m_j}(\mathbf{r}), \quad (7)$$

where the upper (lower) sign corresponds to the incoming (outgoing) electron and $\kappa = (-1)^{j+l+1/2}(j+1/2)$ is the Dirac quantum number. The Wigner matrix $D_{MM'}^J(\mathbf{z} \rightarrow \mathbf{p})$ (see Refs. [28, 30] for details) rotates the \mathbf{z} axis into the \mathbf{p} direction.

The second-order amplitude, corresponding to the dielectronic recombination into one of doubly excited d_1 or d_2 states with subsequent Auger decay, is given by [26, 27]

$$\tau_{\mu_f\mu_i}^{(2)} = (2\pi)^2 \varepsilon \sum_{k=1,2} \sum_{M_{d_k}} \frac{\langle \Psi_f | I | \Psi_{d_k} \rangle \langle \Psi_{d_k} | I | \Psi_i \rangle}{E_i - E_{d_k} + i\Gamma_{d_k}/2}, \quad (8)$$

where E_{d_k} is the energy of the d_k state, $E_i = E_{(1s)^2} + \varepsilon$ is the energy of the initial state, Γ_{d_k} is the total width and M_{d_k} is the momentum projection of the d_k state. The wave functions of the d_1 and d_2 states in the one-electron approximation are given by

$$\begin{aligned} \Psi_{J(J')M}(\mathbf{x}_1, \mathbf{x}_2, \mathbf{x}_3) = B_N \sum_{\mathcal{P}} (-1)^{\mathcal{P}} \mathcal{P} \sum_{M'm_3} \sum_{m_1m_2} C_{J'M', j_3m_3}^{JM} C_{j_1m_1, j_2m_2}^{J'M'} \\ \times \psi_{n_1\kappa_1m_1}(\mathbf{x}_1) \psi_{n_2\kappa_2m_2}(\mathbf{x}_2) \psi_{n_3\kappa_3m_3}(\mathbf{x}_3), \end{aligned} \quad (9)$$

where B_N is the normalization factor.

Having constructed all the relevant parity conserving amplitudes, we now turn to evaluation of the parity violation in the resonance elastic electron scattering. The dominant contribution to the PNC effect in the process of interest is provided by the nuclear spin-independent part of the weak interaction, which can be described by the following effective Hamiltonian [1]

$$H_W = - \left(G_F / \sqrt{8} \right) Q_W \rho_N(r) \gamma_5. \quad (10)$$

Here $Q_W \approx -N + Z(1 - 4\sin^2\theta_W)$ is the weak charge of the nucleus, ρ_N is the nuclear weak-charge density (normalized to unity), G_F is the Fermi constant, and γ_5 is the Dirac matrix. To account for the weak interaction we have to modify the wave functions:

$$|\Psi_{d_1}\rangle \rightarrow |\Psi_{d_1}\rangle + \frac{\langle \Psi_{d_2} | H_W | \Psi_{d_1} \rangle}{E_{d_1} - E_{d_2}} |\Psi_{d_2}\rangle, \quad (11)$$

$$|\Psi_{d_2}\rangle \rightarrow |\Psi_{d_2}\rangle + \frac{\langle \Psi_{d_1} | H_W | \Psi_{d_2} \rangle}{E_{d_2} - E_{d_1}} |\Psi_{d_1}\rangle. \quad (12)$$

To simplify the notations we define the admixing parameter $i\xi = \langle \Psi_{d_1} | H_W | \Psi_{d_2} \rangle / (E_{d_2} - E_{d_1})$. Substituting Eqs. (11) and (12) into Eq. (8) and keeping only the linear terms in ξ one obtains the parity violating amplitude

$$\begin{aligned} \tau_{\mu_f \mu_i}^{\text{PNC}} = & i(2\pi)^2 \varepsilon \xi \sum_{M_d} (\langle \Psi_f | I | \Psi_{d_2} \rangle \langle \Psi_{d_1} | I | \Psi_i \rangle - \langle \Psi_f | I | \Psi_{d_1} \rangle \langle \Psi_{d_2} | I | \Psi_i \rangle) \\ & \times \left(\frac{1}{E_i - E_{d_1} + i\Gamma_{d_1}/2} - \frac{1}{E_i - E_{d_2} + i\Gamma_{d_2}/2} \right). \end{aligned} \quad (13)$$

Here we have utilized the fact that the weak interaction conserves the total momentum projection and, as a result, M_d stands for $M_{d_1} = M_{d_2}$.

One should point out that the nuclear spin-independent part of the weak interaction provides one more contribution to the PNC effect of the process studied. This contribution is related to the scattering by the direct electron-nucleus weak interaction and can be expressed by the amplitude $(2\pi)^2 \varepsilon \langle \Psi_f | H_W | \Psi_i \rangle$. However, we omit this term since it is negligibly small in the framework of the approximations considered. Thus, the amplitude of the resonance elastic electron scattering can be written in the following form

$$\tau_{\mu_f \mu_i} = \tau_{\mu_f \mu_i}^{\text{PC}} + \tau_{\mu_f \mu_i}^{\text{PNC}} \quad (14)$$

with $\tau_{\mu_f \mu_i}^{\text{PC}} = \tau_{\mu_f \mu_i}^{(0)} + \tau_{\mu_f \mu_i}^{(1, \text{dir})} + \tau_{\mu_f \mu_i}^{(1, \text{exc})} + \tau_{\mu_f \mu_i}^{(2)}$ being the parity conserving contribution. Examining the introduced amplitudes with respect to the spatial symmetry leads to the following rules

$$\tau_{\mu\mu}^{\text{PC}} = \tau_{-\mu-\mu}^{\text{PC}}, \quad \tau_{\mu-\mu}^{\text{PC}} = -\tau_{-\mu\mu}^{\text{PC}}, \quad (15)$$

$$\tau_{\mu\mu}^{\text{PNC}} = -\tau_{-\mu-\mu}^{\text{PNC}}, \quad \tau_{\mu-\mu}^{\text{PNC}} = \tau_{-\mu\mu}^{\text{PNC}} = 0. \quad (16)$$

III. RESULTS AND DISCUSSION

In order to enhance the PNC effect in the elastic scattering of polarized electrons by He-like ions, being in the ground state, we assume that the energy of the incident electron is tuned in resonance with doubly-excited opposite-parity $d_1 \equiv [(1s2p_{1/2})_0 n\kappa]_{1/2}$ and $d_2 \equiv [(1s2s)_0 n\kappa]_{1/2}$ states of the corresponding Li-like ions. The quasidegeneracy of these states was found for several n, κ and Z in Ref. [18].

We study the influence of the parity violation on the differential cross section (DCS) $\sigma_{\mu_f \mu_i} \equiv d\sigma_{\mu_f \mu_i}/d\Omega = |\tau_{\mu_f \mu_i}|^2$ of the scattering process. Let us introduce the non-spin-flip $\sigma_{\text{nsf}} = \frac{1}{2} (\sigma_{1/2 \ 1/2} + \sigma_{-1/2 \ -1/2})$ and the spin-flip $\sigma_{\text{sf}} = \frac{1}{2} (\sigma_{1/2 \ -1/2} + \sigma_{-1/2 \ 1/2})$ cross sections. Then, the total DCS is

$\sigma_0 = \sigma_{\text{nsf}} + \sigma_{\text{sf}}$. According to the rules (16), the weak interaction modifies the cross section only in the case when the helicities of the incident and the outgoing electrons coincide ($\mu_i = \mu_f$). As a result, the presence of the PNC effect manifests in deviation of the P-odd contribution $\sigma_{\text{PNC}} = \frac{1}{2} (\sigma_{1/2 \ 1/2} - \sigma_{-1/2 \ -1/2})$ to the cross section from zero. In the present work we consider two scenarios. In the first scenario, the polarization of the outgoing electron is assumed to be detected and only the non-spin-flip contribution to the cross section is considered. In the second scenario the polarization remains unobserved and both σ_{nsf} and σ_{sf} are taken into account. The luminosity of the first (*I*) and second (*II*) scenarios can be expressed as follows [11, 13]

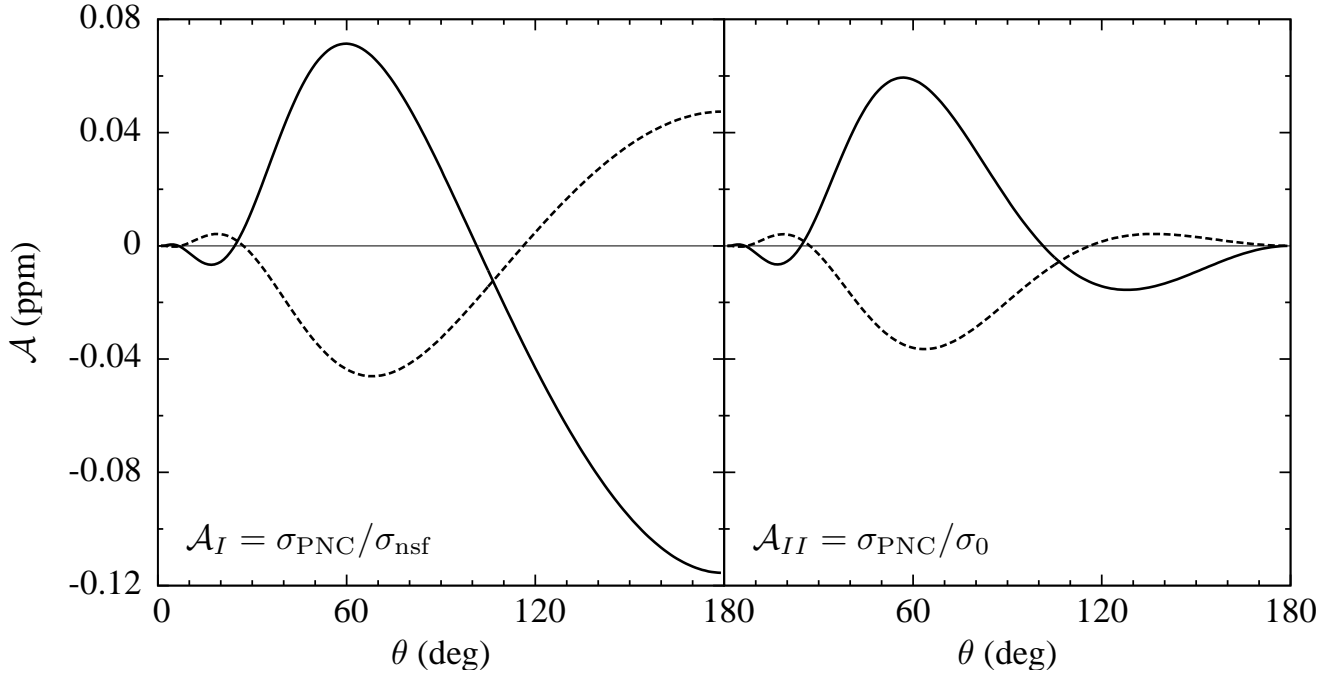
$$L_{I, II} = \frac{\sigma_{I, II} + \sigma_{I, II}^{(b)}}{2\sigma_{\text{PNC}}^2 \eta^2 T}. \quad (17)$$

Here $\sigma_I = \sigma_{\text{nsf}}$ while $\sigma_{II} = \sigma_0$, $\sigma_{I, II}^{(b)}$ corresponds to the background signal, T is the data collection time, and η is the desired relative uncertainty of the PNC effect measurement. In the present analysis we set $\sigma_{I, II}^{(b)} = 0$, T equals to two weeks, and $\eta = 1\%$.

In Fig. 2, the PNC asymmetry coefficients $\mathcal{A}_I = \sigma_{\text{PNC}}/\sigma_{\text{nsf}}$ and $\mathcal{A}_{II} = \sigma_{\text{PNC}}/\sigma_0$ for the elastic electron scattering on He-like samarium ($Z = 62$) are displayed as functions of the scattering angle θ in the case of resonance with the $[(1s2s)_0 \ 7s]_{1/2}$ and $[(1s2p_{1/2})_0 \ 7s]_{1/2}$ states. Since these coefficients are directly related to the magnitude of the PNC effect, one can conclude that for the first scenario the parity violation is expected to become most significant at large scattering angles. In the case when the polarization of the scattered electron is not detected (second scenario) the most promising situation occurs for $\theta \sim 60^\circ$, while at larger scattering angles a strong suppression of the P-odd asymmetry is observed. This is due to the fact that at large scattering angles the dominant contribution to the DCS is provided by the P-even spin-flip amplitude, which does not interfere with the PNC amplitude according to Eqs. (16).

In Fig. 3, the parity violating asymmetry of the resonance electron scattering on He-like samarium ($Z = 62$) is depicted as a function of the incident electron energy for three different scattering angles (60, 110 and 175 degrees). From this figure one can see that the peak magnitude of the P-odd asymmetry is expected for the energy of the scattering electron close to resonance which is provided by the $[(1s2s)_0 \ 7s]_{1/2}$ state. Here it is worth to mention that the parameters, being related to the maximum magnitude of the parity violating asymmetry, may not provide the best value of the luminosity, and vice versa. In order to find the optimal relation we propose the following procedure. First, one should pick out scattering angles at which the P-odd asymmetry has the same order of magnitude as the maximal

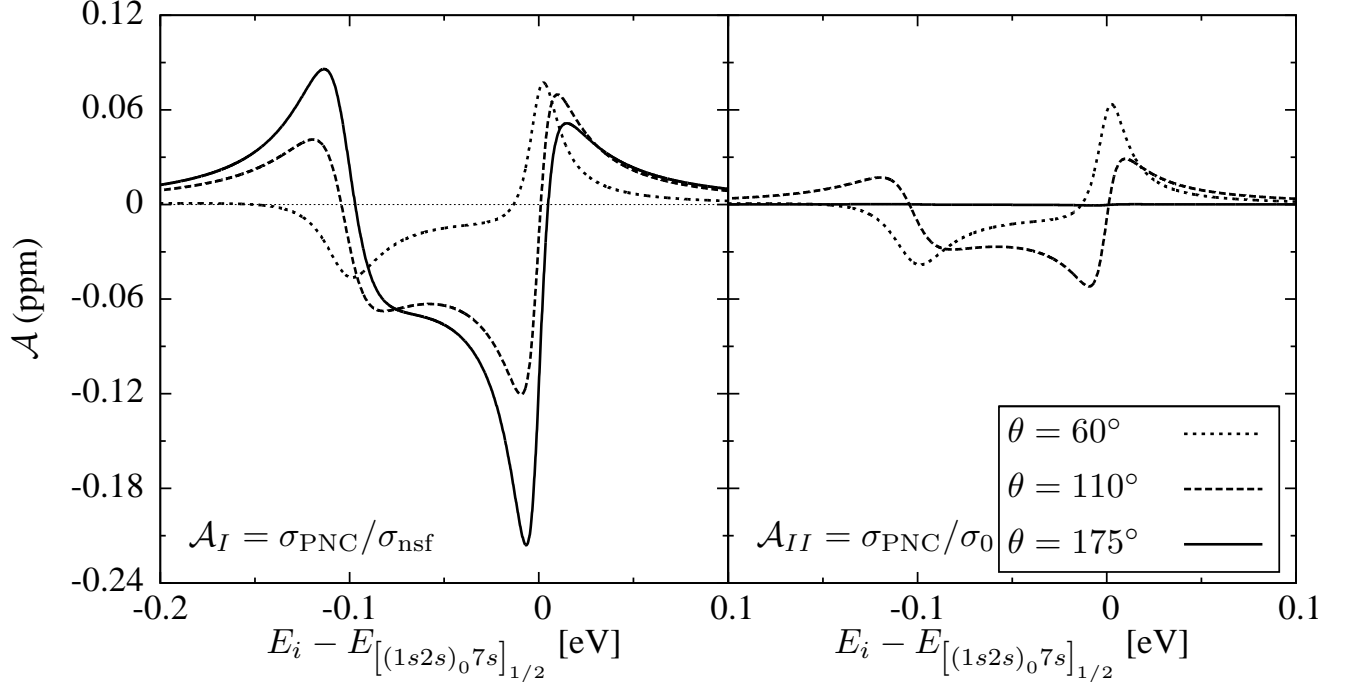
FIG. 2. The P-odd asymmetry of the resonance elastic electron scattering on He-like samarium ($Z = 62$) for two different scenarios. In the first scenario (left graph) the polarization of the scattered electron is detected and in the second scenario the polarization is remained unobservable (right graph). The solid and the dashed lines correspond to the cases of the incident electron energy being tuned in resonance with $[(1s2s)_0 7s]_{1/2}$ and $[(1s2p_{1/2})_0 7s]_{1/2}$ states of the Li-like samarium, respectively.



one. Among them the optimal relation is provided by such an angle which corresponds to the minimum of the luminosity. As an example, let us consider the scenario where the polarization of the outgoing electron is detected (first scenario). For the case of the samarium ion (see Fig. 3) the maximal value of \mathcal{A}_I is expected for the scattering angle 175° and equals -2.2×10^{-7} , while L_I for these parameters is equal to $7.1 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$. The optimal relation between \mathcal{A}_I and L_I is expected for $\theta \sim 108^\circ$ where they take the values -1.2×10^{-7} and $6.5 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$, respectively.

In Tables I and II we present the numerical results for the parameters n , κ and Z which seem to be most promising for measuring the PNC effect in the process of resonance elastic electron scattering on He-like ions. It is assumed that the energy of the incident electron is tuned in vicinity of the resonance, being related to the $[(1s2s)_0 n\kappa]_{1/2}$ state, to provide the peak value of the P-odd asymmetry. In Table I we present the results for the case when the polarization of the scattered electron is measured (first scenario). The results for the second scenario, where the polarization of the outgoing electron is not

FIG. 3. The asymmetry coefficients $\mathcal{A}_I = \sigma_{\text{PNC}}/\sigma_{\text{nsf}}$ (left graph) and $\mathcal{A}_{II} = \sigma_{\text{PNC}}/\sigma_0$ (right graph) of the resonance elastic electron scattering on He-like samarium ($Z = 62$). The difference $E_i - E_{[(1s2s)_0 7s]_{1/2}}$ fixes the energy of the incoming electron. The solid line corresponds to $\theta = 175^\circ$, the dashed and dotted lines are related to the cases of scattering at angles 110° and 60° , respectively.



detected, are represented in Table II.

From Table I one can see that for the first scenario the PNC effect is expected to be most pronounced for scattering on the samarium ($Z = 62$) ion at the energy of the incident electron tuned in vicinity of resonance corresponding to the $[(1s2s)_0 7s]_{1/2}$ state. In this case, the optimal values of the asymmetry and the luminosity equal to -1.2×10^{-7} and $6.5 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$, respectively, and are achieved for the scattering angle $\sim 108^\circ$. This system seems also to be most preferable for the second scenario (Table II), where the polarization of the scattered electron is not detected. In this scenario the optimal values $\mathcal{A}_{II} = 4.9 \times 10^{-8}$ and $L_{II} = 1.0 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$ are obtained at $\theta \sim 45^\circ$. From these tables one can conclude that the observation of the outgoing electron polarization does not allow to increase significantly the PNC effect.

The requirement of the electron production with high and controllable degree of spin polarization and accurate energy tuning makes it presently impossible to investigate the P-odd effects in the process of interest. Perhaps, some of the difficulties can be avoided by studying inelastic electron scattering,

TABLE I. Cross section of the resonance elastic electron scattering on He-like ions for parameters n , κ and Z which seem to be most promising for measuring the PNC effect. The energy of the incident electron is tuned in vicinity of resonance corresponding to the $[(1s2s)_0 n\kappa]_{1/2}$ state. It is assumed that the polarization of the scattered electron is detected. The energy difference $\Delta E = E_{[(1s2p_{1/2})_0 n\kappa]_{1/2}} - E_{[(1s2s)_0 n\kappa]_{1/2}}$ is taken from Ref. [18]. The scattering angle θ provides the optimal relation between the P-odd asymmetry $\mathcal{A}_I = \sigma_{\text{PNC}}/\sigma_{\text{nsf}}$ and the luminosity L_I , which is defined by Eq. (17). σ_0 and σ_{nsf} are the total and non-spin-flip cross sections, respectively, and σ_{PNC} stands for the parity violating contribution to the cross section.

Z	$n\kappa$	ΔE (eV)	ε_i (keV)	θ (deg)	\mathcal{A}_I	L_I (cm ⁻² s ⁻¹)	σ_0 (b)	σ_{nsf} (b)	σ_{PNC} (b)
60	6s	-0.222(56)	36.40	163	-1.0×10^{-7}	2.7×10^{33}	4.8×10^3	1.5×10^2	-1.5×10^{-5}
62	7s	-0.103(64)	39.56	108	-1.2×10^{-7}	6.5×10^{31}	1.0×10^4	4.7×10^3	-5.5×10^{-4}
90	6s	2.51(47)	88.36	64	-3.3×10^{-8}	1.7×10^{32}	2.5×10^4	2.2×10^4	-7.2×10^{-4}
	7s	1.75(47)	89.22	57	3.8×10^{-8}	9.3×10^{31}	3.4×10^4	3.0×10^4	1.2×10^{-3}
92	5s	2.97(28)	91.43	66	-3.8×10^{-8}	1.4×10^{32}	2.3×10^4	2.0×10^4	-7.6×10^{-4}
	6s	-1.07(28)	92.95	74	-1.0×10^{-7}	3.1×10^{31}	1.6×10^4	1.3×10^4	-1.3×10^{-3}

where one could get rid of the dominant zero-order (in $1/Z$) contribution to the PC amplitude, thus reducing the suppression of the PNC effect. One may also think, that the corresponding investigations with other heavy few-electron ions can lead to a bigger effect. We expect that the calculations performed in the present paper can serve as a proper basis for further study in these directions.

IV. CONCLUSION

In the present work the PNC effect has been studied in the elastic scattering of polarized electrons by heavy He-like ions, being initially in the ground state. In order to enhance the parity violation effect, the energy of the incident electron has been chosen to provide a resonance with one of the quasidegenerate doubly-excited $[(1s2s)_0 n\kappa]_{1/2}$ and $[(1s2p_{1/2})_0 n\kappa]_{1/2}$ states of the corresponding Li-like ion. We have considered two different scenarios. In the first scenario we assume that the polarization of the scattered electron was measured. In the second one the polarization was supposed to be unobservable. It has been found that for both variants the PNC effect occurs to be most pronounced for scattering on

TABLE II. Cross section of the resonance elastic electron scattering on He-like ions for parameters n , κ and Z which seem to be most promising for measuring the PNC effect. The energy of the incident electron is tuned in vicinity of resonance corresponding to the $[(1s2s)_0 n\kappa]_{1/2}$ state. It is assumed that the polarization of the scattered electron is not detected. The energy difference $\Delta E = E_{[(1s2p_{1/2})_0 n\kappa]_{1/2}} - E_{[(1s2s)_0 n\kappa]_{1/2}}$ is taken from Ref. [18]. The scattering angle θ provides the optimal relation between the P-odd asymmetry $\mathcal{A}_{II} = \sigma_{\text{PNC}}/\sigma_0$ and the luminosity L_{II} , which is defined by Eq. (17). σ_0 and σ_{nsf} are the total and non-spin-flip cross sections, respectively, and σ_{PNC} stands for the parity violating contribution to the cross section.

Z	$n\kappa$	ΔE (eV)	ε_i (keV)	θ (deg)	\mathcal{A}_{II}	L_{II} (cm ⁻² s ⁻¹)	σ_0 (b)	σ_{nsf} (b)	σ_{PNC} (b)
60	6s	-0.222(56)	36.40	43	2.2×10^{-8}	4.0×10^{31}	2.1×10^5	1.9×10^5	4.6×10^{-3}
62	7s	-0.103(64)	39.56	45	4.9×10^{-8}	1.0×10^{31}	1.6×10^5	1.5×10^5	8.0×10^{-3}
90	6s	2.51(47)	88.36	59	-2.7×10^{-8}	1.8×10^{32}	3.2×10^4	2.8×10^4	-8.4×10^{-4}
	7s	1.75(47)	89.22	58	3.5×10^{-8}	1.0×10^{32}	3.2×10^4	2.9×10^4	1.1×10^{-3}
92	5s	2.97(28)	91.43	62	-3.2×10^{-8}	1.5×10^{32}	2.7×10^4	2.4×10^4	-8.5×10^{-4}
	5p _{1/2}	-0.511(27)	91.44	46	2.2×10^{-8}	1.2×10^{32}	6.8×10^4	6.3×10^4	1.5×10^{-3}

samarium ion at the energy of the incident electron tuned in vicinity of resonance, which is related to the $[(1s2s)_0 7s]_{1/2}$ state. In the case of the first scenario the peak value of the PNC asymmetry equals to -1.2×10^{-7} at $\theta \sim 108^\circ$, while in the second scenario the P-odd asymmetry is 4.9×10^{-8} for the scattering angle $\theta \sim 45^\circ$. These values are too small to make possible performing the corresponding experiment. We think, however, that the calculations presented can be considered as the first necessary step towards investigations of the PNC effect with electron scattering by heavy ions.

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